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# Hardness Evolution and Electrochemical Behavior of Copper-Alloyed 2205 Duplex Stainless Steel Aged at 400°C

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## Introduction

Duplex stainless steels (DSS) exhibit a balanced ferritic-austenitic microstructure, providing an attractive combination of high mechanical strength and excellent corrosion resistance [1].
Copper has attracted increasing interest as an alloying element in DSS because it can improve mechanical performance through precipitation hardening while also providing antibacterial properties for applications susceptible to microbiologically influenced corrosion. Nevertheless, the effect of Cu on corrosion resistance remains controversial [2].
Thermal aging at intermediate temperatures promotes microstructural transformations that contribute to the hardening of Cu-containing duplex stainless steels [3].

## Objectives

This work aims to investigate how different Cu additions influence the evolution of age hardening during aging at 400 °C and to correlate the mechanical response with the electrochemical behaviour of 2205 duplex stainless steel.

## Methodology

1. Preparation of 2205 DSS specimens with four Cu contents (0.5Cu, 1.5Cu, 2Cu and 3Cu).
2. Solution and aging heat treatments at 400 °C.
3. Hardness tests.
4. Electrochemical tests.

## Results

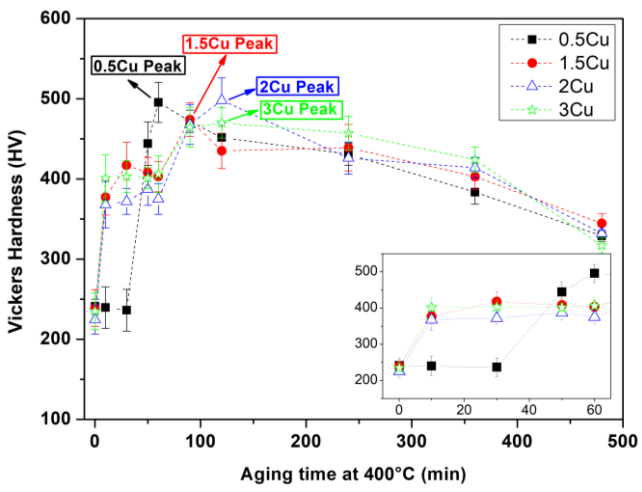



Figure 1. Evolution of hardness of 2205 DSS with different Cu contents during aging at 400 °C.

Table 1. Peak hardness, standard deviation (SD) and corresponding aging time for 2205 DSS with different Cu contents aged at 400 °C.

| Alloy | 0.5Cu | 1.5Cu | 2Cu | 3Cu |
|---|---|---|---|---|
| **Hardness (HV) peak** | 495 | 474 | 498 | 470 |
| **SD** | 25 | 21 | 28 | 19 |
| **Time to peak (min)** | 60 | 90 | 120 | 120 |

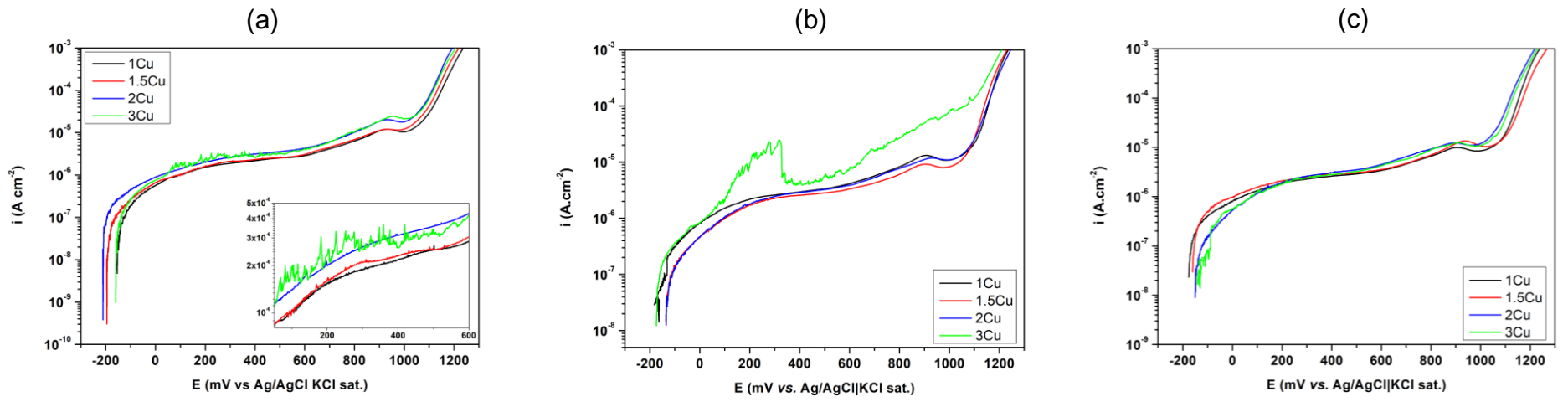



Figure 2. Potentiodynamic polarization curves of 2205 DSS with different Cu contents in the (a) solution-treated, (b) peak-aged, and (c) overaged conditions after aging at 400 °C.

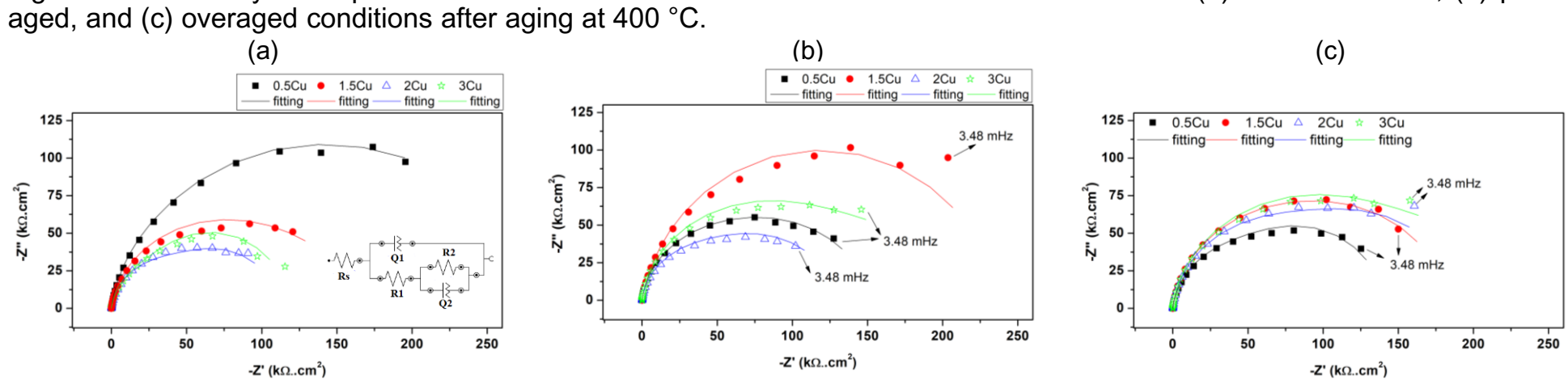



Figure 3. Nyquist diagrams of 2205 DSS with different Cu contents in the solution-treated (a), peak-hardening (b) and overaged (c) conditions after aging at 400 °C. Equivalent circuit shown in (a).

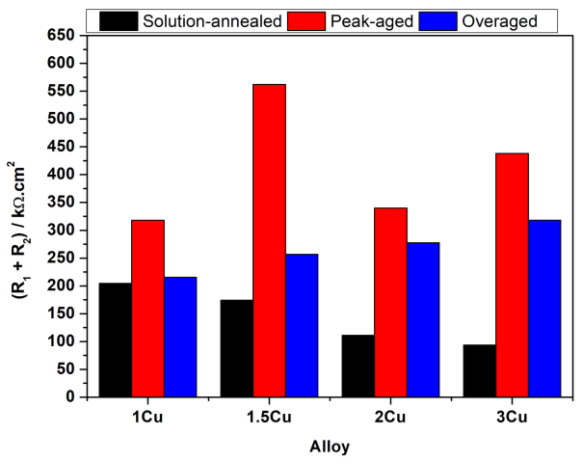



Figure 4 - Estimated polarization resistance ($R_1$+$R_2$) obtained from electrochemical impedance spectroscopy (EIS) fitting for DSS samples with different Cu contents in the solution-annealed, peak-aged, and overaged conditions.

## Conclusions

It can be concluded that all alloys reached similar peak hardness (470–498 HV), although higher Cu contents delayed the peak. The 1.5Cu alloy exhibited a favorable balance between hardness (474 HV) and electrochemical resistance (R1 + R2 = 562 kΩ·cm²) at peak aging.

## References and Acknowledgements

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